Field Trip I: Harvard Museum of Natural History (HMNH)

Objectives

To observe the diversity of animals. To compare and contrast the various adaptations, body plans, etc. of the animals found at the HMNH.

Introduction

The most casual observation indicates that not all animals look the same. Darwin's theory of evolution through the process of natural selection tells us that the reason animals (or plants) do not look the same is that they have evolved to fit into particular environmental niches and that most differences which we observe reflect some kind of special adaptation to the environment. One of the easiest ways to examine the changes which have occurred during the course of evolution is to visit the Harvard Museum of Natural History at Harvard University. Here, mounted animal specimens from all parts of the world are arranged in groups according to their evolutionary relationships as well as the geographic regions in which they are found. The purpose of this lab is to examine these animals and for you to teach yourself certain principles of animal diversity by using your own observations to answer the questions in these pages.

You should also visit the Glass Flowers exhibit in the same museum. It contains glass models of many important plant types.

You can easily walk from the Harvard Square MBTA station to the HMNH (see map on next page). It is best to go to Harvard Square by subway (red line) or by bus since parking places around the museum are either enormously difficult to find, or they are reserved for the faculty and staff of Harvard (and reserved parking is strictly enforced). The trip from UMass to the HMNH takes about 45 minutes each way.

You will need to pick up a ticket to the HMNH in lecture; this will get you free admission (it is normally $5 for students). You can go to the HMNH anytime that the museum is open. TAs will be at the HMNH during all of the scheduled lab periods during the week listed on the syllabus. The HMNH is open daily 9:00 AM to 5:00 PM. Admission is free (even without a ticket) Sundays from 9 to 12 and Wednesdays from 3 to 5.

YOU SHOULD BRING YOUR COPIES OF *Campbell* and the *Lab Atlas* FOR REFERNCE.

Procedure

VERY IMPORTANT NOTICE: This lab will take you a while to complete, especially if you are unprepared. In order to be able to complete it in 3 hours, you should **be sure to do the following before you go to the HMNH**:

• Read up on classification systems (*Campbell* pp 537 - 538) and familiarize yourself with terms like kingdom, phylum, etc.The following phyla can be found at the HMNH; you should go through *Campbell* and make a brief sketch of each phylum so you can recognize it more easily when you are looking for it (each of these is listed in the index):

- chordata
- cnidaria
- angiospermae
- platyhelminthes
- coniferophyta
- arthropoda
- cyanobacteria
- lycophyta
- mollusca

Read over **all the questions** and make a plan of how you might go about answering them.

At the HMNH

Be sure to get a map - it will show you where to find various types of organisms.

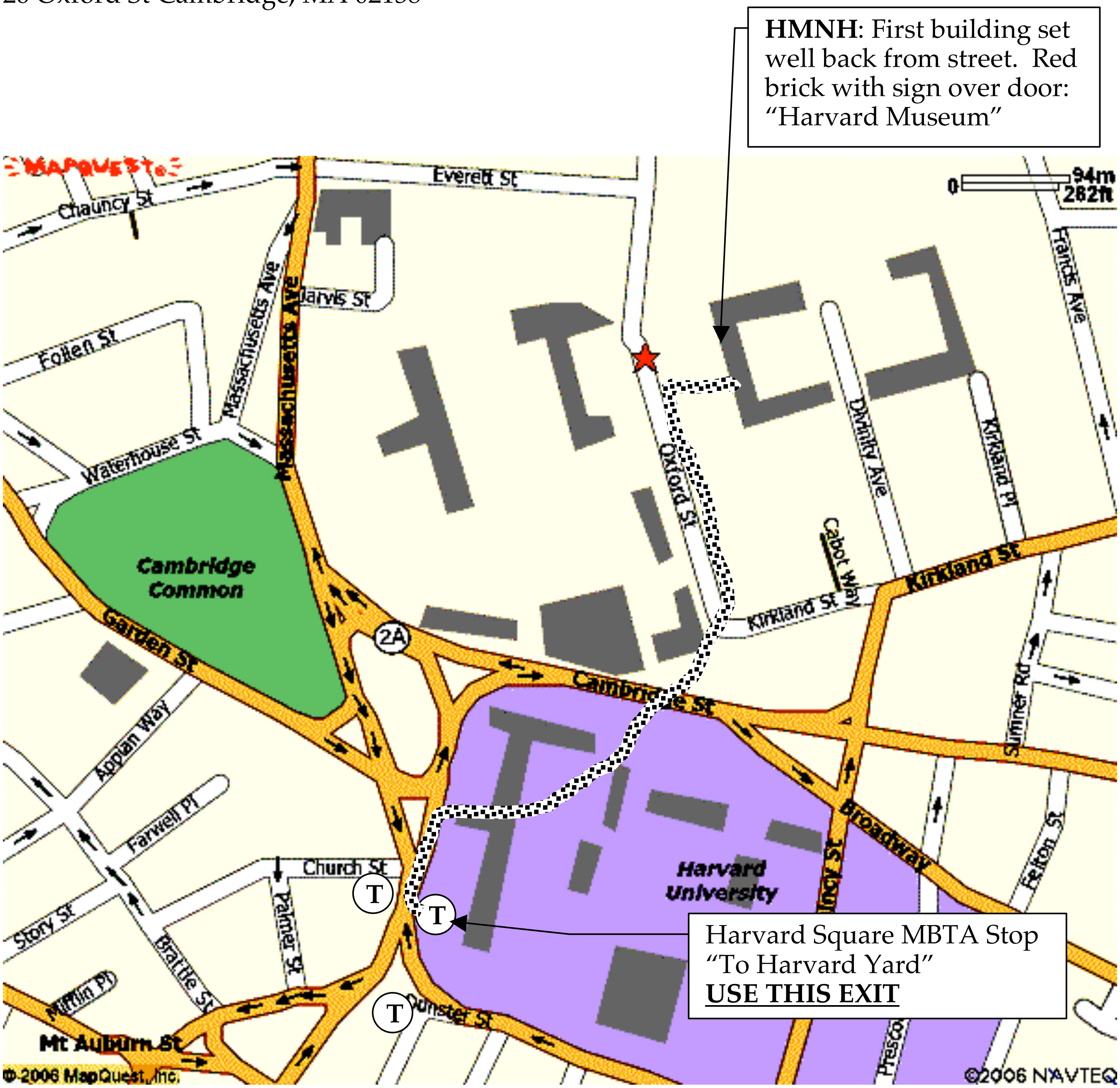
During your visit, you should make notes from which you can answer the questions below. Your lab report will consist of answers to these questions. You need only to answer the questions; it is not necessary to assemble your answers into a larger essay.

Lab report:

- Important note: these questions are difficult & involve some speculation & interpretation on your part. For that reason, we will grade your responses generously. Our purpose is to get you thinking about these issues rather than to emphasize a specific right answer. As long as your answers are reasonable and clearly-explained, you should get full credit.
- Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine; photographs are not acceptable.
- Due at the start of the lab session you are currently in during the week listed on the syllabus. This is a firm deadline.
- Although you will perform these activities as a group, each member of the group must turn in an individual lab report. Each person's report must be in his or her own words as much as possible.
- Your lab report must contain answers to the questions on pages HMNH-4 through HMNH-9.

Getting to the HMNH (not all buildings shown)

26 Oxford St Cambridge, MA 02138



- Exit Harvard station using the "To Harvard yard" exit.
- Go along Massachusetts Ave with the brick and wrought iron fence on your right.
- Go through the first gate you come to; it's near a bus stop.
- Go diagonally across Harvard yard to the gate at the north end (you'll see a big plaza).
- Cross the plaza with the Science Center on your left.
- Cross the street at the corner where Kirkland and Oxford intersect.
- Walk along Oxford with the street on your left until you come to the HMNH.

1) Phyla
Choose three different phyla listed in *Campbell*. For each of the three phyla, find one representative organism at the HMNH or Glass Flowers Exhibit. Be sure to list its genus and species names in addition to its common name (if available). In one brief sentence, describe the organism (size, coloration, feeding, habitat, etc.).

a) Phylum #1____________

organism: Genus________________________

Species_____________________________

Common name (if available)__________________________________

Description:

b) Phylum #2__________________

organism: Genus________________________

Species_____________________________

Common name (if available)__________________________________

Description:

c) Phylum #3____________

organism: Genus________________________

Species_____________________________

Common name (if available)__________________________________

Description:

2) Convergent Evolution
Consider the wing bones of the following three flying vertebrates:

- Pterandon – a flying dinosaur. Its skeleton can be found on the wall in the Romer Hall of Vertebrate Paleontology.
- Bird. A bird (Northern Harrier) skeleton can be found on the balcony in the Hall of Mammals with the hawks.
- Bat – flying mammal. A bat skeleton can be found in the Hall of Mammals in case A2 which is against the wall that separates the Hall of Mammals room from the Holarctic Mammals and Birds room.

All three wing structures are based on the same tetrapod vertebrate arm and five-fingered hand structure that is shown in *Campbell* figure 22.17.

Using figure 22.17 as a guide, sketch the wing bones of a bird, a bat, and a pterandon and identify (as best you can) how the bones in each of your sketches correspond to the bones in the human arm and hand. Be sure to label the parts of the wing skeleton that correspond to:

- Humerus (upper arm bone) {shown in gray in figure 22.17}
- Radius & ulna (lower arm or "forearm" bones) {orange and beige}
- Palm & finger bones (carpals, phalanges, & metacarpals) {yellow and brown}

For each wing, give a one-sentence description of its structure. For example, if we had asked about figure 22.17, you would say something like, "The whale's flipper is like a human hand, but with very long fingers."

3) Common Structures

Virtually all tetrapod vertebrates (see Lab Atlas figure 8.74 for a sample) have the following features (among many others): Numbers in parentheses refer to numbered parts in figure 8.74.

- Two "legs" – appendages near the tail end of the backbone (#23 - #28).
- Two "arms" – appendages near the head end of the backbone (#3 - #8).
- A "tail" – an extension of the backbone beyond the pelvis at the back end of the animal (#22).

These have been extensively modified in certain swimming vertebrates; for example:

- Whales - marine mammals. Several whale skeletons can be found hanging from the ceiling in the Hall of Vertebrates (you can't miss 'em).
- Seals – another group of marine mammals. A seal skeleton can be found by the windows in the Hall of Mammals.

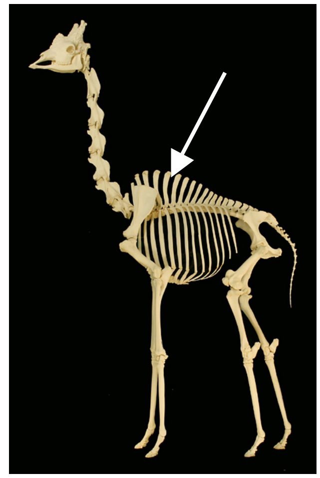
a) To which part(s) (arm, leg, tail) do the front flippers of a whale correspond?

b) How have the leg bones of a "standard tetrapod" been modified in a whale?

c) To which part(s) (arm, leg, tail) does the "tail" (the part(s) of the animal at the back end that are moved up and down for swimming) of a whale correspond?

d) To which part(s) (arm, leg, tail) does the "tail" (the part(s) of the animal at the back end that are moved up and down for swimming) of a seal correspond?

4) Skeletal Morphology and Function



A giraffe skeleton is shown at the right. The arrow indicates the "neural spines" which are bony projections sticking up from the thoracic vertebrae. The thoracic vertebrae are the parts of the backbone to which the ribs are attached; they are indicated by number 16 in figure 8.74 of the *Lab Atlas*.

Muscles connect the neural spines to the bones of the neck; these muscles are used to hold the animal's head up and keep the neck from dropping down. The stronger these muscles have to be, the larger they must be and the larger the neural spines have to be. Thus, a giraffe, which must hold up a very long and heavy neck, has very large neural spines. Note that a long neck may not be the only reason for large neural spines - other factors are sometimes involved.

For each of the following animals:

a) State whether the neural spines are:

- **Large** - like the giraffe's, which are much larger than the corresponding projections on the lumbar vertebra (see #17 in figure 8.74 of the *Lab Atlas*).
- **Small** - not much larger than the corresponding projections on the lumbar vertebra (see #17 in figure 8.74 of the *Lab Atlas*).

Note that we are interested in the *relative* size of the spines compared to the size of the skeleton of that animal, not their *absolute* size in inches.

b) Provide a plausible explanation for why this is so.

As an example, here is a satisfactory answer for the giraffe skeleton:
a) The neural spines on the giraffe skeleton are ***LARGE in comparison to its size****.*
b) This indicates that the muscles attached to the neural spines must be large and therefore strong. This is likely because the giraffe has a long and heavy neck that it must hold up and away from the body.

Answer questions (a) and (b) for the following animals. All of these skeletons can be found in the Hall of Mammals.

- Moose

- Whale

- Human

5) Marine Mammals I: Skeletons and External Anatomy

This is the first part of a three-part exploration of marine mammal anatomy, diversity, and phylogeny. In each of the three parts, you will address the following two questions using evidence collected during the lab:

a) How many major different phylogenetic groups of marine mammals are there? The answer to this lies somewhere between "All marine mammals are so similar that they are really only one big group." and "Each one is so different that there are 20 different groups." How will you resolve this? You look for similarities and differences and decide for yourself if the similarities are enough to put a few organisms into a phylogenetic group or if the differences are compelling enough to split them up.
A full-credit answer to this question consists of three parts:
   - The number of groups of marine mammals that you have determined.
   - An explanation of why you chose the groups that you chose. We are not interested in the "right" answer here; just a well-reasoned argument based on your observations. What are the key differences between groups? What are the key features that make members of each group similar? This part must include a *data table* of the format described on the next page and an explanation of how you used the data in the table to draw the conclusions you drew.
   - Which of the marine mammals from the list below belong to each group?

   The following marine mammals can be found at the HMNH:
   - Amazon Manatee
   - Fur Seal
   - Harbor Porpoise
   - Harbor Seal
   - Narwhal
   - Right Whale
   - River Otter
   - Sea Otter
   - Sperm Whale

b) Which is the closest living land relative of a seal? Seals evolved from land-dwelling ancestors. Although that ancestor is now extinct, it has modern-day descendants. Based on the evidence you collect, you must decide which order of land mammals this ancestor came from. You must choose one group and defend your choice.
A full-credit answer to this question has two parts:
   - The order of land mammals that you think is most closely-related to the land ancestor of seals. Choose from the list below.
   - An explanation of why you chose that phylogenetic order. As above, you must provide a *data table* in the format specified on the next page and an explanation of how you used the data in the table to draw the conclusions you did. Again, we are not interested in the "right" answer; just a well-reasoned argument based on your observations.

   These are the major orders of land mammals that can be found in the Hall of Mammals:
   - Marsupialia
   - Insectivora
   - Chiroptera
   - Primates
   - Rodentia
   - Carnivora
   - Perissodactyla
   - Artiodactyla

In each part, we are not interested in the correct answer; we are interested in the *data* you cite and your *argument* based on that data. The more specific about the data you are and the more clear your argument is, the more credit you will get.

In this part, you will use external and skeletal anatomy to answer these questions. You should look at the whole animals and the skeletons found in the HMNH to collect data to formulate your answer to each question.

Phylogenetic Data Tables in Bio 112

When studying evolution, it is very important to choose the *characters* - the particular features of the organisms under study - very carefully. Even though we will not be concerned here with the 'correct' characters, it is important to start thinking rigorously. For that reason, when making arguments based on observations of organisms, we will require you to be very specific about the characters and traits you are comparing and to specify these in a table format.

First, some definitions:

- **Character** - a feature of an organism. For example, "leg form" or "number of eyes".
- **Trait** - a particular form of a character. For example: the character "leg shape" could have the traits "long", "bent", and "none"; these would be used to describe organisms with long legs, bent legs, and no legs. Similarly, the character "number of eyes" could have the traits "two" and "none".

When answering the questions in the lab manual that require this format, you should first examine the organisms in question, then make a list of the characters you will study, and finally compile a table like the one below (a hypothetical table based on comparing some small animals). The table has one row for each organism and one column for each character; the cells in the table contain the traits.

Organism	Segmented body?	Legs	Exoskeleton
Honeybee	Yes	6	Yes
Ant	Yes	6	Yes
Millipede	Yes	250	Yes
Slug	No	0 (1?)	No

When making tables like this for your lab reports, you should use at least 4 characters; you can use more if you like.

You could then make an argument that there are two groups of organisms based on this data. It could go something like this, "There are two groups of organisms here. One has an exoskeleton, segmented body, and 6 or more legs - the honeybee, and, and millipede are all part of this group. The other group lacks these features and includes the slug. The reason these are two different groups is that members of the first group share three of the characters listed with each other while the other does not. Thus, the members of one group are more similar to each other than they are to the slug."